

X-SECTION F

Worksheet for Irregular Channel

Future 100yr

Project Description	
Worksheet	X-SECTION F
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.024000 ft/ft
Discharge	69.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.016
Water Surface Elevation	98.92 ft
Elevation Range	98.39 to 99.05
Flow Area	16.0 ft ²
Wetted Perimeter	95.03 ft
Top Width	94.04 ft
Actual Depth	0.53 ft
Critical Elevation	99.01 ft
Critical Slope	0.006469 ft/ft
Velocity	4.30 ft/s
Velocity Head	0.29 ft
Specific Energy	99.20 ft
Froude Number	1.84
Flow Type	Supercritical

Dxv

$$(0.53)(4.30) = 2.3 < 6 \quad \checkmark$$

Calculation Messages:
Flow is divided.

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	7+00	0.013
7+00	108+00	0.017
108+00	115+00	0.013

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	98.99
5+00	98.89
5+50	98.89
5+50	98.39
7+00	98.56
65+00	98.96
108+00	98.62
109+50	98.45

X-SECTION F

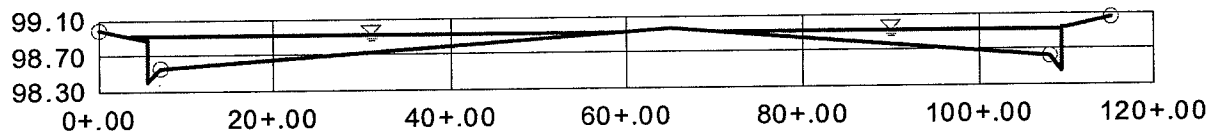
Cross Section for Irregular Channel

Project Description

Worksheet	X-SECTION F
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data

Mannings Coefficient	0.016
Channel Slope	0.024000 ft/ft
Water Surface Elevation	98.92 ft
Elevation Range	98.39 to 99.05
Discharge	69.00 cfs



V:10.0
H:1
NTS



Exhibit-2
Survey Info

SPLIT Flow AT

Deer Springs + John Herbert

Buffalo, 100-yr flow split to north Worksheet for Irregular Channel

Project Description	
Worksheet	Buffalo, flow to north
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data	
Channel Slope	0.024000 ft/ft
Water Surface Elevation	98.96 ft

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.017
Elevation Range	98.39 to 98.99
Discharge	58.09 cfs
Flow Area	12.5 ft ²
Wetted Perimeter	64.01 ft
Top Width	63.50 ft
Actual Depth	0.57 ft
Critical Elevation	99.06 ft
Critical Slope	0.006168 ft/ft
Velocity	4.65 ft/s
Velocity Head	0.34 ft
Specific Energy	99.30 ft
Froude Number	1.85
Flow Type	Supercritical

← Flow in Buffalo going Northward when WSE is at crown of road. Regardless of storm event.

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	7+00	0.013
7+00	65+00	0.017

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	98.99
5+00	98.89
5+50	98.89
5+50	98.39
7+00	98.56
65+00	98.96

$$\begin{aligned} &\text{Flow Northward in Buffalo} \\ &= 58 \text{ cfs} + (271 - 58 - 47) \cdot 2 \\ &= 91 \text{ cfs} \leftarrow 100 \text{ yr} \end{aligned}$$

$$\begin{aligned} &\text{Existing} \\ &10 \text{ yr} \\ &= 58 \text{ cfs} + (164 - 58 - 47) \cdot 2 \\ &= 70 \text{ cfs} \end{aligned}$$

$$\begin{aligned} &\text{Future 100 yr} \\ &= 58 + (162 - 58 - 47) \cdot 0.2 \\ &= 69 \text{ cfs} \end{aligned}$$

$$\begin{aligned} &\text{Future 10 yr} \\ &= \frac{58}{58 + 47} \left(\frac{X}{68} \right) = 38 \text{ cfs} \end{aligned}$$

took ratio of flows

Buffalo, 100-yr, flow split to north

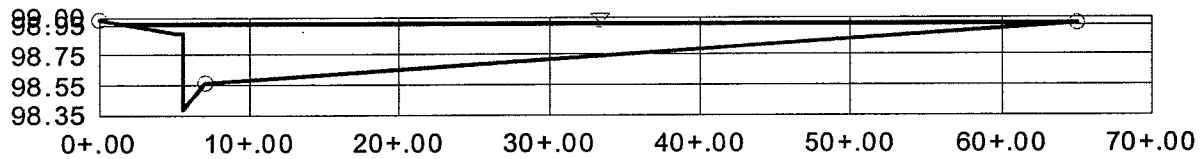
Cross Section for Irregular Channel

Project Description

Worksheet	Buffalo, flow to north
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data

Mannings Coefficient	0.017
Channel Slope	0.024000 ft/ft
Water Surface Elevation	98.96 ft
Elevation Range	98.39 to 98.99
Discharge	58.09 cfs



V:10.0
H:1
NTS

Worksheet for Irregular Channel

Project Description	
Worksheet	John Herbert Capacity
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data	
Channel Slope	0.002000 ft/ft
Water Surface Elevation	98.96 ft

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.016
Elevation Range	98.75 to 99.29
Discharge	46.50 cfs
Flow Area	38.3 ft ²
Wetted Perimeter	242.93 ft
Top Width	242.93 ft
Actual Depth	0.21 ft
Critical Elevation	98.90 ft
Critical Slope	0.007722 ft/ft
Velocity	1.21 ft/s
Velocity Head	0.02 ft
Specific Energy	98.98 ft
Froude Number	0.54
Flow Type	Subcritical

← say 240 LF of weir
Compared to approx. 60 LF going northward
∴ thus, the flows to the north are 20%
of the remaining.

$$.20 \left(\text{Total Flow} - \underset{\text{up to crown}}{58 \text{ cfs}} - \underset{\text{John H crown}}{47 \text{ cfs}} \right)$$

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	272+00	0.016

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	99.29
37+00	98.87
100+00	98.76
159+00	98.75
190+00	98.76
218+00	98.78
242+00	98.85
272+00	98.96

Flow crossing into John Herbert

$$= 47 + (271 - 58 - 47)(.8)$$
$$= 180 \text{ cfs}$$

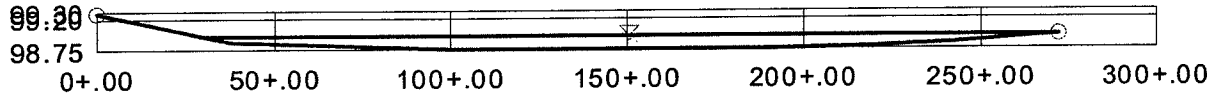
John Herbert, flow at crown HP on Buffalo
Cross Section for Irregular Channel

Project Description

Worksheet	John Herbert Capacity
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data

Mannings Coefficient	0.016
Channel Slope	0.002000 ft/ft
Water Surface Elevation	98.96 ft
Elevation Range	98.75 to 99.29
Discharge	46.50 cfs



V:20.0
H:1
NTS

Storm Drain

- Inlets
- Std. Form 6

INLETS 1 AND 2
Worksheet for Combination Inlet On Grade

Project Description

Worksheet	Combination Inlet - 1
Type	Combination Inlet On Grade
Solve For	Efficiency

Input Data

Discharge	23.50 cfs	- 47 cfs both sides
Local Depression	2.0 in	
Local Depression Width	1.50 ft	
Channel Slope	0.008300 ft/ft	
Gutter Width	1.50 ft	
Gutter Cross Slope	0.083 ft/ft	
Road Cross Slope	0.020 ft/ft	
Mannings Coefficient	0.013	
Curb Opening Length	4.00 ft	
Grate Width	1.50 ft	
Grate Length	4.00 ft	
Grate Type	P-50 mm (P-1-7/8")	
Clogging	50.0 %	

Options

Calculation Option	Use Both
Grate Flow Option	Exclude None

Results

Efficiency	0.30	
Total Intercepted Flow	7.05 cfs	← 14 cfs total for both sides.
Bypass Flow	16.45 cfs	
Spread	22.31 ft	
Depth	0.53 ft	
Flow Area	4.7 ft²	
Gutter Depression	1.1 in	
Total Depression	3.1 in	
Velocity	4.56 ft/s	
Splash Over Velocity	8.13 ft/s	
Frontal Flow Factor	1.00	
Side Flow Factor	0.04	
Grate Flow Ratio	0.20	
Equivalent Cross Slope	0.054063 ft/ft	
Active Grate Length	2.00 ft	
Length Factor	0.05	
Total Interception Length	41.84 ft	

INLETS 1 AND 2

Worksheet for Combination Inlet On Grade

100 yr flow

Project Description

Worksheet	Combination Inlet - 1
Type	Combination Inlet On Grade
Solve For	Efficiency

Input Data

Discharge	51.50 cfs
Local Depression	2.0 in
Local Depression Width	1.50 ft
Channel Slope	0.008300 ft/ft
Gutter Width	1.50 ft
Gutter Cross Slope	0.083 ft/ft
Road Cross Slope	0.020 ft/ft
Mannings Coefficient	0.013
Curb Opening Length	4.00 ft
Grate Width	1.50 ft
Grate Length	4.00 ft
Grate Type	P-50 mm (P-1-7/8")
Clogging	50.0 %

103 cfs total flow

Options

Calculation Option	Use Both
Grate Flow Option	Exclude None

Results

Efficiency	0.22
Total Intercepted Flow	11.13 cfs
Bypass Flow	40.37 cfs
Spread	30.10 ft
Depth	0.68 ft
Flow Area	8.8 ft ²
Gutter Depression	1.1 in
Total Depression	3.1 in
Velocity	5.56 ft/s
Splash Over Velocity	8.13 ft/s
Frontal Flow Factor	1.00
Side Flow Factor	0.03
Grate Flow Ratio	0.15
Equivalent Cross Slope	0.044847 ft/ft
Active Grate Length	2.00 ft
Length Factor	0.03
Total Interception Length	65.08 ft

- 22 cfs total both sides

Worksheet for Combination Inlet On Grade

Project Description

Worksheet	Combination Inlet - 3&4
Type	Combination Inlet On Grade
Solve For	Efficiency

Input Data

Discharge	16.50 cfs
Local Depression	2.0 in
Local Depression Width	1.50 ft
Channel Slope	0.008300 ft/ft
Gutter Width	1.50 ft
Gutter Cross Slope	0.083 ft/ft
Road Cross Slope	0.020 ft/ft
Mannings Coefficient	0.013
Curb Opening Length	4.00 ft
Grate Width	1.50 ft
Grate Length	4.00 ft
Grate Type	P-50 mm (P-1-7/8")
Clogging	50.0 %

$$\text{total flow} = 33 \text{ cfs} = (47 - 14)$$

Options

Calculation Option	Use Both
Grate Flow Option	Exclude None

Results

Efficiency	0.35
Total Intercepted Flow	5.74 cfs
Bypass Flow	10.76 cfs
Spread	19.47 ft
Depth	0.47 ft
Flow Area	3.6 ft ²
Gutter Depression	1.1 in
Total Depression	3.1 in
Velocity	4.16 ft/s
Splash Over Velocity	8.13 ft/s
Frontal Flow Factor	1.00
Side Flow Factor	0.05
Grate Flow Ratio	0.24
Equivalent Cross Slope	0.059316 ft/ft
Active Grate Length	2.00 ft
Length Factor	0.06
Total Interception Length	34.12 ft

say 11 cfs both sides

INLETS 2 AND 3

Worksheet for Combination Inlet On Grade

1004r

Project Description

Worksheet	Combination Inlet - 3&4
Type	Combination Inlet On Grade
Solve For	Efficiency

Input Data

Discharge	40.50 cfs
Local Depression	2.0 in
Local Depression Width	1.50 ft
Channel Slope	0.008300 ft/ft
Gutter Width	1.50 ft
Gutter Cross Slope	0.083 ft/ft
Road Cross Slope	0.020 ft/ft
Mannings Coefficient	0.013
Curb Opening Length	4.00 ft
Grate Width	1.50 ft
Grate Length	4.00 ft
Grate Type	P-50 mm (P-1-7/8")
Clogging	50.0 %

81 cfs total flow (103 - 22)

Options

Calculation Option	Use Both
Grate Flow Option	Exclude None

Results

Efficiency	0.24
Total Intercepted Flow	9.68 cfs
Bypass Flow	30.82 cfs
Spread	27.47 ft
Depth	0.63 ft
Flow Area	7.3 ft²
Gutter Depression	1.1 in
Total Depression	3.1 in
Velocity	5.23 ft/s
Splash Over Velocity	8.13 ft/s
Frontal Flow Factor	1.00
Side Flow Factor	0.03
Grate Flow Ratio	0.16
Equivalent Cross Slope	0.047356 ft/ft
Active Grate Length	2.00 ft
Length Factor	0.04
Total Interception Length	56.94 ft

say 19 cfs total both sides

Worksheet for Combination Inlet On Grade

Project Description

Worksheet	Combination Inlet - 4&3
Type	Combination Inlet On Grade
Solve For	Efficiency

Input Data

Discharge	11.00 cfs
Local Depression	2.0 in
Local Depression Width	1.50 ft
Channel Slope	0.008300 ft/ft
Gutter Width	1.50 ft
Gutter Cross Slope	0.083 ft/ft
Road Cross Slope	0.020 ft/ft
Mannings Coefficient	0.013
Curb Opening Length	4.00 ft
Grate Width	1.50 ft
Grate Length	4.00 ft
Grate Type	P-50 mm (P-1-7/8")
Clogging	50.0 %

22 cfs total (33 - 11)

Options

Calculation Option	Use Both
Grate Flow Option	Exclude None

Results

Efficiency	0.41
Total Intercepted Flow	4.52 cfs
Bypass Flow	6.48 cfs
Spread	16.63 ft
Depth	0.41 ft
Flow Area	2.6 ft ²
Gutter Depression	1.1 in
Total Depression	3.1 in
Velocity	3.75 ft/s
Splash Over Velocity	8.13 ft/s
Frontal Flow Factor	1.00
Side Flow Factor	0.06
Grate Flow Ratio	0.28
Equivalent Cross Slope	0.066376 ft/ft
Active Grate Length	2.00 ft
Length Factor	0.07
Total Interception Length	26.90 ft

say 9 cfs total

Combined flow off street

For 10 yr is (14 + 11 + 9) = 34 cfs

into the
storm drain

48" EQUIVALENT
Worksheet for Circular Channel

Project Description

Worksheet	BUFFALO
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Mannings Coefficient	0.013
Channel Slope	0.003800 ft/ft
Diameter	48.0 in
Discharge	90.00 cfs

Results

Depth	3.34 ft
Flow Area	11.2 ft ²
Wetted Perimeter	9.22 ft
Top Width	0.00 ft
Critical Depth	2.88 ft
Percent Full	83.5 %
Critical Slope	0.005227 ft/ft
Velocity	8.03 ft/s
Velocity Head	1.00 ft
Specific Energy	4.34 ft
Froude Number	0.73
Maximum Discharg	95.25 cfs
Discharge Full	88.54 cfs
Slope Full	0.003926 ft/ft
Flow Type	Subcritical

← Maximum Capacity includes 35 cfs
from existing 24".

42" RCP 0.6% SLOPE
Worksheet for Circular Channel

Project Description

Worksheet	42" RCP
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data

Mannings Coefficient	0.013
Channel Slope	0.008000 ft/ft
Depth	2.80 ft
Diameter	42.0 in

Results

Discharge	87.96 cfs
Flow Area	8.3 ft ²
Wetted Perimeter	7.75 ft
Top Width	0.00 ft
Critical Depth	2.92 ft
Percent Full	80.0 %
Critical Slope	0.007433 ft/ft
Velocity	10.66 ft/s
Velocity Head	1.77 ft
Specific Energy	4.57 ft
Froude Number	1.09
Maximum Discharg	96.80 cfs
Discharge Full	89.98 cfs
Slope Full	0.007644 ft/ft
Flow Type	Supercritical

Worksheet for Circular Channel

Project Description	
Worksheet	36" RCP
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data	
Mannings Coefficient	0.013
Channel Slope	0.008000 ft/ft
Depth	2.40 ft
Diameter	36.0 in

Results	
Discharge	58.31 cfs
Flow Area	6.1 ft ²
Wetted Perimeter	6.64 ft
Top Width	0.00 ft
Critical Depth	2.47 ft
Percent Full	80.0 %
Critical Slope	0.007577 ft/ft
Velocity	9.62 ft/s
Velocity Head	1.44 ft
Specific Energy	3.84 ft
Froude Number	1.07
Maximum Discharg	64.17 cfs ← max
Discharge Full	59.65 cfs
Slope Full	0.007644 ft/ft
Flow Type	Supercritical

— 58 cfs (capacity)

$$\begin{aligned}
 100\text{-ft Flow} &= Q_{24"} + Q_{12"} \\
 &= 35 + 22 \\
 &= \underline{57 \text{ cfs}} \leftarrow
 \end{aligned}$$

* Note: the 58 cfs is taken at (0.8)D thus pipes are not near capacity nor are they under pressure.

48 0.8% SLOPE
Worksheet for Circular Channel

Project Description	
Worksheet	48" RCP 0.8% SLOPE
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data	
Mannings Coefficient	0.013
Channel Slope	0.008000 ft/ft
Depth	3.20 ft
Diameter	48.0 in

Results	
Discharge	125.58 cfs
Flow Area	10.8 ft ²
Wetted Perimeter	8.86 ft
Top Width	0.00 ft
Critical Depth	3.36 ft
Percent Full	80.0 %
Critical Slope	0.007320 ft/ft
Velocity	11.65 ft/s
Velocity Head	2.11 ft
Specific Energy	5.31 ft
Froude Number	1.12
Maximum Discharge	138.20 cfs
Discharge Full	128.47 cfs
Slope Full	0.007644 ft/ft
Flow Type	Supercritical

Worksheet for Circular Channel

Project Description

Worksheet	36" RCP
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Mannings Coefficient	0.013
Channel Slope	0.019000 ft/ft
Diameter	36.0 in
Discharge	76.00 cfs

1.9%

Results

Depth	2.08 ft
Flow Area	5.2 ft ²
Wetted Perimeter	5.90 ft
Top Width	0.00 ft
Critical Depth	2.73 ft
Percent Full	69.3 %
Critical Slope	0.011339 ft/ft
Velocity	14.53 ft/s
Velocity Head	3.28 ft
Specific Energy	5.36 ft
Froude Number	1.86
Maximum Discharge	98.89 cfs
Discharge Full	91.93 cfs
Slope Full	0.012985 ft/ft
Flow Type	Supercritical

2.08'

Worksheet for Circular Channel

Project Description

Worksheet	36" RCP
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Mannings Coefficient	0.013
Channel Slope	0.028700 ft/ft
Diameter	36.0 in
Discharge	57.00 cfs

2.87%

Results

Depth	1.51 ft
Flow Area	3.6 ft ²
Wetted Perimeter	4.73 ft
Top Width	0.00 ft
Critical Depth	2.45 ft
Percent Full	50.3 %
Critical Slope	0.007372 ft/ft
Velocity	16.02 ft/s
Velocity Head	3.99 ft
Specific Energy	5.50 ft
Froude Number	2.59
Maximum Discharge	121.54 cfs
Discharge Full	112.99 cfs
Slope Full	0.007304 ft/ft
Flow Type	Supercritical

1.51'

Worksheet for Circular Channel

Project Description

Worksheet	36" RCP
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Mannings Coefficient	0.013
Channel Slope	0.012300 ft/ft
Diameter	36.0 in
Discharge	57.00 cfs

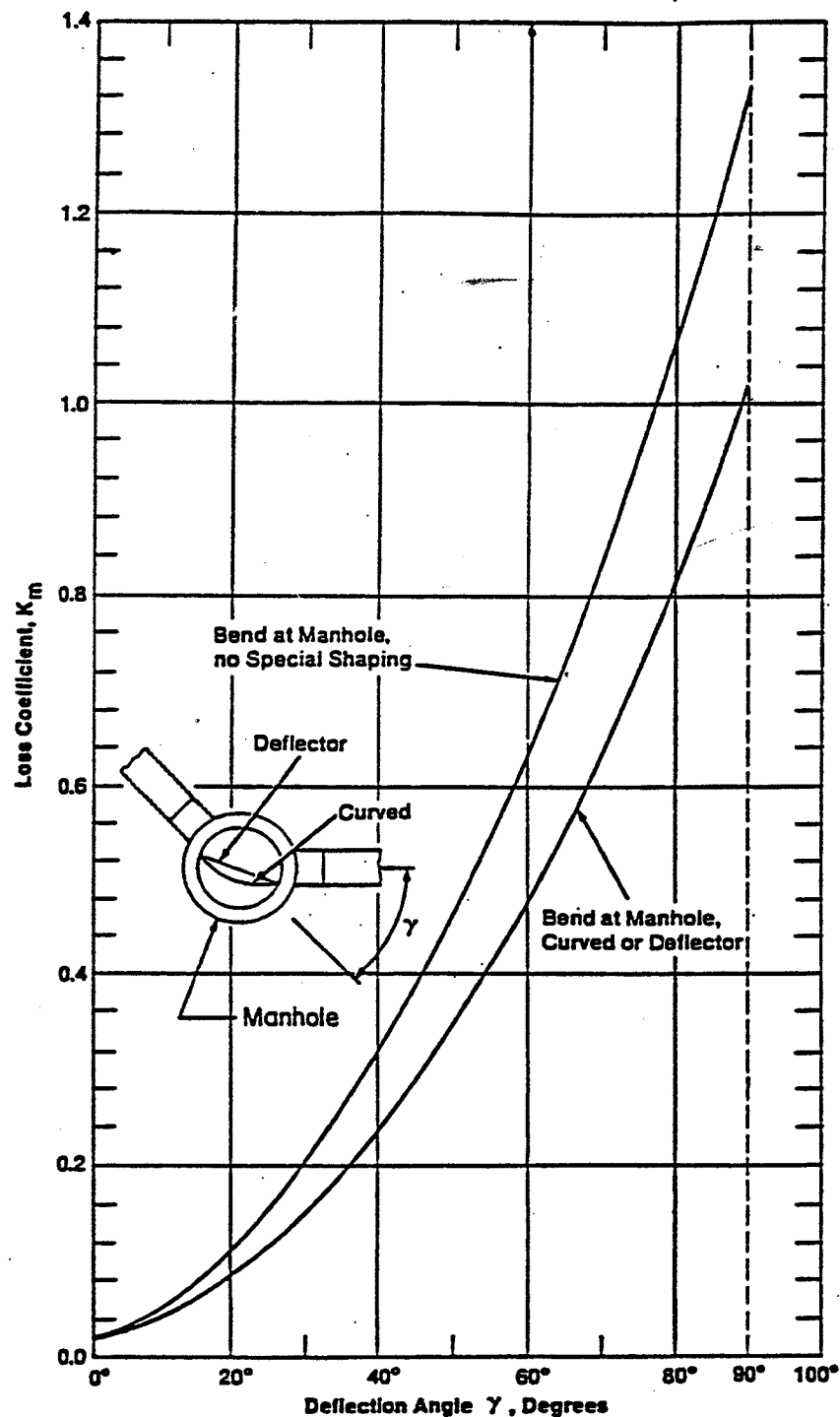
1.23%

Results

Depth	1.98 ft
Flow Area	4.9 ft ²
Wetted Perimeter	5.68 ft
Top Width	0.00 ft
Critical Depth	2.45 ft
Percent Full	65.9 %
Critical Slope	0.007372 ft/ft
Velocity	11.55 ft/s
Velocity Head	2.07 ft
Specific Energy	4.05 ft
Froude Number	1.55
Maximum Discharge	79.57 cfs
Discharge Full	73.97 cfs
Slope Full	0.007304 ft/ft
Flow Type	Supercritical

2'

ENERGY LOSS COEFFICIENT IN STRAIGHT THROUGH MANHOLE



NOTE: Head loss applied at outlet of manhole.

Revision	Date

